Breeding for Disease and Insect Resistance in Hardwoods

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Pest resistance often is the major consideration in tree breeding and, always must be taken into account.

Although little breeding for pest resistance in southern hardwoods has been undertaken the need for it has been recognized_ It should receive increased attention because of: (1) the disadvantages of pesticides; (2) the probable increase in pests with increase in hardwood. planting; and (3) the ease of vegetatively propagating some species.

I will discuss resistance and breeding methods as they relate to southern hardwoods.

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HOW RESISTANCE IS TESTED

By resistance, we generally do not mean immunity but only a greater ability than normal to withstand some pest.

Disease resistance is governed by morphological or physiological variation of the host. Thus, such morphological variations as a slightly thickened epidermis, cork formation, or lignin or cutin development may prevent the germ tube of a fungus spore from entering the host plant. Physiological variation may prevent the development of the disease. For example, attack is prevented when the cell sap of a host is so concentrated or so acid that a fungus cannot thrive or live, or when substances toxic to the fungus are present in the cell protoplasm, or when growth substances essential to the fungus are lacking.

Resistance to insects usually is complex and varies with each insect and host. Segaard (1964) lists three mechanisms: (1) preference or nonpreference of the insect for the host; (2) antibiosis, the detrimental effects of the plant on the biology of the insect; and (3) tolerance, the ability of the plant to withstand an insect population that might damage a more susceptible host.

In breeding for pest resistance, the first step often is to select resistant individuals out of a host population that is heavily attacked by the pest. As Schreiner (1960) points out, however, the search should not be limited to populations that have been exposed since resistant genes often occur in nonexposed populations.

Following selection, controlled cross-pollination between resistant clones of the same or different species often leads to further improvement. To reveal the pattern of inheritance of resistance, Venkatesh (1963) proposed five methods of controlled breeding: 1) Self-pollination of resistant trees found in an infected stand 2) Cross-pollination between pairs of resistant trees 3) Self-pollination of diseased trees 4) Cross-pollination between pairs of diseased trees 5) Cross-pollination between diseased and healthy trees.

When the host is highly susceptible, induced mutation may confer resistance. Methods of inducing mutation include X-rays, radio waves, neutrons, a-particles, b-particles, chemical agents, and temperature shocks.

After the apparently resistant host has been found, either through selection, hybirdization, or induced mutation, it must be subjected to clonal tests that take into account the three-way relationship between host, parasite, and environment.

A detailed knowledge of the life history of the fungus or the biology and feed habits of the insect is basic in any resistance studies, for it enables the worker to distinguish true genetic resistance, and to separate types of resistance.

Populations of the pest must be maintained. As Painter (1951) says, "The most useful insect population is one which gives the maximum difference between resistant and susceptible types." When natural populations are not satisfactory for testing for resistance, the experimenter resorts to inoculations or caged populations. The validity of such controlled tests must be checked repeatedly under field conditions. Massive inoculations with pathogens, or cage tests with insects, may be so severe that they assess immunity rather than relative resistance.

In any test, a susceptible, well-known variety is useful as a standard of comparison.

In discussing tests for disease resistance, Schreiner (1963) stresses the need for considering (1) the establishment and progress of parasitism; (2) the nature of host resistance; (3) the biology and genetic variability of the pathogen; and (4) the effect of internal and external environmental factors on host-resistance, on pathogenicity and. virulence of the pathogen, and. on the host-pathogen relationship.

Artificial inoculations may be confounded by variations in the time of inoculation and the assessment of results, the procedure, and the age of the host.

DISEASES

I will review breeding possibilities in southern hardwoods under the four major types of diseases: wood rots, leaf diseases, cankers, and diebacks and wilts.

Wood rots. --Heart rots cause more volume loss in southern hardwoods than all other diseases combined. Tree species of first importance include eastern cottonwood. (*Populus deltoides* Bartr.), sweetgum (*Liquidambar styraciflua* L.), and the oaks (*Quercus* spp.). The fact that several dozen fungi are involved will make the development of resistant clones particularly difficult. Furthermore, direct tests of resistance must be delayed until selections have become old enough to form heartwood. Although no active research is under way as yet, the possibilities are indicated by a recent study in which heartwood of cherrybark oak (*Quercus falcata* var. *pagodaefolia* Ell.) growing on good sites was more resistant to decay by *Pleurotus ostreatus* (Jacq.) Fr. than heartwood of trees growing on poor sites (Toole, 1963). An example from the Northeast is resistance to wood decays in *Robinia pseudoacacia* L.: the clone called shipmast locust is highly resistant to four rot fungi that badly damage other clones (Hirt, 1938; Toole, 1938).

Leaf diseases. --Heavy infections of *Melampsora* rust on cottonwood, leaf blister on oak, anthracnose on sycamore and oak, and other leaf fungi occur periodically in the South. The possibilities of breeding for resistance to these leaf diseases appear excellent. At Stoneville a start has been made on *Melampsora* rust. This disease has long been a serious pest of various *Populus* species throughout the world, and several workers outside the South have developed resistant clones (Chiba, 1964; Schreiner, 1963) that are widely cultivated in both the United. States and Europe.

In recent studies on resistance to the leaf rust caused by *M. laricipopulina* Klebahn in Japan, Chiba (1964) found marked differences in susceptibility among sections of *Populus* as well as clonal differences within sections. Clones of poplar resistant to the *Septoria* and. *Marssonia* leaf diseases have been selected in Italy (Castellani, 1964).

Cankers.--Most of the common canker fungi in southern hardwoods are associated, with trees of low vigor growing in mixed stands. As planting expands the acreage of pure stands, canker fungi are likely to increase in importance. *Cytospora* canker on cottonwood. has on occasion reached. epiphytotic proportions in plantations in the Mississippi Delta. No breeding for resistance to cankers is being done in the South, but in other parts of the world. *Populus* clones resistant to a number of canker diseases have been selected and, propagated in the last 40 years(Donaubauer, 1964; Muhle, 1963; Persson, 1955, 1962; Schreiner 1949, 1963).

The canker or bark disease called chestnut blight has practically exterminated the American chestnut. Selection for resistance has not been successful, although sprouts have shown juvenile resistance. The failure of selection is probably due to the fact that blight resistance is not inherited as a dominant characteristic (Clapper and. Gravatt, 1943). During the first 10 years after the blight struck, it was found that the oriental species were resistant. Several thousand hybrids have been produced with varieties and strains of Chinese and Japanese chestnuts, Chinese chinkapin, American chestnut, and native chinkapins. Some of the first-generation hybrids of Chinese and American chestnut show promise of resistance when grown on suitable sites. The most promising hybrid is an American x Chinese backcrossed with the American parent (Diller and Clapper, 1965).

Diebacks and wilts .--A number of diebacks and wilts occur in southern forests. At present none need. prime consideration, but breeding for resistance to several hardwood wilt diseases is possible.

An example is the wilt of the mimosa tree. This disease was already widespread in the southeastern United States in 1939, when selection for resistance was started. Fifty seemingly resistant trees--scattered from Maryland to Louisiana--were located, and their seedlings were inoculated with the wilt fungus. Twenty of the seedling trees survived 8 years or longer, and two clones have been distributed commercially (Toole and Hepting, 1949).

Another example is the work with elm trees. American elms are threatened by both the

Dutch elm disease and the virus-caused phloem necrosis. Resistance to the Dutch elm disease in the uniformly susceptible tetraploid. Ulmus americana L. seems to be governed by many minor genes, and selection has not been useful. Thus, 32,000 seedlings from seed collected from 309 elms were all susceptible: it seems unlikely that resistant strains occur in nature (Ouellet, 1964).

Arisumi and Higgins (1961) have demonstrated resistance in a clone of U. hollandica X (U. carpinifolia X U. pumila). Subtropical elms show resistance (Smalley and. Riker, 1962) and can be crossed with the generally susceptible American elm. However, lack of cold.-hardiness increases susceptibility to Nectria canker (Heybroek, 1957).

In Canada, tests were made of 146,000 American elm seedlings from seed treated with X-rays or thermal-neutrons. Four seedlings were considered promising--two from seed treated with X-rays and two from seed treated with thermal-neutrons. One of the former has remained free of symptoms after seven consecutive years of inoculation. The others showed only light symptoms in 2 of the 7 years (Ouellet, 1964).

With the virus disease of elm, phloem necrosis, selections for resistance were made among open-pollinated. stock collected. from an area where the disease had occurred for over 50 years (Swingle, 1942).

INSECTS

The wood borers and defoliators are the most damaging southern hardwood insects, and hence are of chief concern in the search for insect-resistant trees.

Wood borers.--Trunk-boring and bark-scarring insects attack living hardwoods and cause defects in the wood which seriously degrade and lower values for lumber and veneer. Average loss may be over $20 per thousand board feet for oak lumber. The selection of resistant strains should, be encouraged. Although no research is under way, local observation by entomologists at Stoneville has discovered individual trees possibly resistant to the carpenterworm, one of the most important borers. Black locust is the only example of successful selection for resistance to borers--resistant clones have been developed. (Hall, 1937 and Heybroek, 1957).

Defoliators.--Outbreaks of hardwood defoliators occur frequently. An example is the forest tent caterpillar, which seriously reduces growth in southern gum forests, destroys flowers so that no seed develops, and may kill trees and cause stand deterioration. One undamaged sweetgum was observed by Stoneville entomologists in an area where all others had been defoliated. It is likely that such a tree is resistant. There are no records of active research on breeding for resistance to defoliators, but possible resistance to leaf-feeding insects in poplar has been reported. by Riker (1954) and Schreiner (1949).

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